Sigmodon hispidus Say and Ord, 1825
Hispid Cotton Rat

Sigmodon hispidus Say and Ord, 1825:354. Type locality St. Johns River, northeastern Florida.

Sigmodon baileyi Allen, 1903:601. Type locality La Chienega de las Vacas, 6,500 ft., Durango.

Sigmodon berlandieri Baird, 1855:333. Type locality Rio Nazas, Cosahuila.

Sigmodon brancae Allen, 1897:40. Type locality Boruca, near Rio Diiquis, 1,600 ft., about 12 mi. from Pacific Coast, Puntarenas, Costa Rica.

Arvicola texiana Audubon and Bachman, 1853:229. Type locality Brazos River, Texas.


Sigmodon zanjonensis Goodwin, 1932:1. Type locality Zanjon, 9,000 ft., Quezaltenango, Guatemala.

CONTEXT AND CONTENT. Order Rodentia, Suborder Myomorpha, Family Muridae, Subfamily Cricetinae. A generic account and key to the species of Sigmodon was presented in Baker and Shump (1978). The following 25 subspecies of S. hispidus were recognized by Hall and Kelso (1959); other subspecies then recognized have been removed to separate species Sigmodon arizonae and S. mascostaei:


S. h. baileyi Allen, 1903:601, see above.

S. h. berlandieri Baird, 1855:333, see above (pallidus Mearns a synonym).

S. h. brancae Allen, 1897:40, see above (austerus Bangs a synonym).

S. h. chiriqensis Allen, 1904:68. Type locality Boqueron, Chiriqui, Panama.


S. h. eremicus Mearns, 1897:504. Type locality Ginegwa Well, 30 mi. S Monument No. 204, Mexican boundary line, on east bank Colorado River, Sonora.

S. h. exspatus Allen, 1920:236. Type locality Big Pine Key, one of the southern Florida Keys, Monroe Co., Florida.

S. h. floridanus Howell, 1943:75. Type locality Canal Point, Palm Beach Co., Florida.

S. h. furrus Bangs, 1903:39. Type locality La Cieba, Atlantida, Honduras.

S. h. griseus Allen, 1908:657. Type locality lowlands east of Lake Nicaragua, Chontales, Nicaragua.

S. h. hispidus Say and Ord, 1825:354, see above.

S. h. inequus Elliot, 1903:144. Type locality Octlan, Jalisco.


S. h. loricilis Chapman, 1889:118. Type locality East Peninsula, opposite Micco, Brevard Co., Florida.

S. h. microdon Bailey, 1902:111. Type locality Puerto Morelos, Quintana Roo.


S. h. saturatus Bailey, 1902:111. Type locality Teapa, Tabasco.

S. h. solus Hall, 1951:42. Type locality island 88 mi. S, 10 mi. W Matamoros, Tamaulipas.

S. h. spadicius Bangs, 1898:192. Type locality Cape Sable, Monroe Co., Florida.

S. h. texanus (Audubon and Bachman, 1853:229), see above.

S. h. toltecais (Sauzaure, 1869:98), see above.

S. h. tosalensis Bailey, 1902:109. Type locality Tonalá, Chiapas.


S. h. zanjonensis Goodwin, 1932:1, see above.

DIAGNOSIS. Sigmodon hispidus differs from the S. fulviventris group in possessing large tail scales (0.75 mm wide rather than 0.5 mm wide) and a tail sparsely haired instead of heavily haired. The skull is generally long and narrow, baiosicopital length and broad, palatal pits shallow, as opposed to a short and broad skull, long and narrow or short and broad baiosicopital, and deeply marked palatal pits in S. fulviventris group (Baker, 1969).

S. hispidus differs from other members of the S. hispidus group by having a generally shorter hind foot (less than 34 mm long, 32 mm), shorter distance between temporal and occipital crests (less than 3.6 mm, averaging 3.2 mm) and the diameter of the foramen ovale less than three-fourths the diameter of M3. S. hispidus has a well-developed crest on the posterior of the palate (Zimmerman, 1970).

Cranial characters allow separation of S. hispidus from S. arizonae. The flattened ventral surface of the presphenoid is wider in arizonae than hispidus with lateral sides of the presphenoid visible only in hispidus (Severinghaus and Hoffmeister, 1978). The anterior spine on the infrabrainal plate is more elongated and pointed in arizonae. The occipital shield of arizonae has a rounded dorsal ridge whereas it is angular in hispidus.

GENERAL CHARACTERS. Fig. 1 shows the external appearance of the hispid cotton rat. Typical adult sizes (in mm) are: total length 224 to 365, length of tail 81 to 166, length of hindfoot 28 to 41, length of ear 16 to 24 (Chipman, 1965; Hall and Kelso, 1959; Jimenez, 1971). Adult body weights range from 110 to 225 g for males and 100 to 200 g for females (Chipman, 1965). Sexual dimorphism has been reported for length of body (Chipman, 1965; Jimenez, 1971; McIntire et al., 1944), length of hindfoot (Jimenez, 1971), and body weight (Chipman, 1965). McLennan (1971) reported that northern populations (Kansas) exhibit greater morphological variation than southern (Mexico) populations.

The skull is illustrated in Fig. 2. Cranial measurements (in mm) for adults are (n = 27): condylobasal length, 40.9 (39.1 to 42.5); symphathic breadth, 23.7 (22.1 to 25.4); height of braincase, 15.8 (14.8 to 17.3); length of nasal, 16.5 (15.3 to 18.0); alveolar length of maxillary toothrow, 7.6 (7.1 to 8.2); greatest length of

Figure 1. The hispid cotton rat (Sigmodon hispidus texanus). Photographed at the University of Houston Coastal Center by S. R. Spencer.
DISTRIBUTION. The geographic range of the hispid cotton rat extends northward from northern South America (Kibbly, 1969) through most of Central America and Mexico and into the southeastern and southwestern United States (Fig. 3). S. hispidus extends from Florida north to Virginia, west to Kansas and Nebraska, southwest to southern New Mexico and southeastern Arizona. An isolated population near Yuma, Arizona, extends into western Mexico, southern Arizona, and southwestern California along the Colorado River and in the Imperial Valley.

Recent reports have documented extensions in the species range, primarily northward into central Virginia (Pagels and Adlemen, 1971), Kentucky (Robinson and Quick, 1965); northern Missouri (Easterla, 1960), southern Nebraska (Farney, 1975); Genoways and Schlitter, 1967; Jones, 1960); and northern New Mexico (Mohlenbrink, 1961). Carey (1978) reported a western movement in Colorado and Dixon (1972) reported a spread westward from Colorado River drainage into the Imperial Valley of California (see also Clark, 1972).

FOSSIL RECORD. The fossil record of Sigmodon was reviewed by Martin (1979). Sigmodon is believed to have evolved from a grass-eating cricetine ancestor which developed as a progressive offshoot from the main line of phyllostine rodent origin (Herskovitz, 1962). The genus is presumed to be tropical American in origin, evolving either in South or Middle American grasslands in the late Pliocene (Baker, 1969; Herskovitz, 1966; Hooper, 1949), although Martin (1979) suggested a North American origin. Martin (1979) speculated that S. hispidus dispersed into South America over the Panamanian land bridge during the early Blancan and radiated into its present habitat types during the Rancholabrean.

Sigmodon hispidus is known from the Rancholabrean in Florida, the Sangamon (third interglacial) in the Moore Pit Pleistocene fauna of northern Texas, and may have been present in this region throughout the Wisconsin glaciation (Slaughter, 1966, 1967). Cushing (1945) and Gilmore (1947) reported Sigmodon from the Mexican Quaternary and Recent deposits, respectively. S. hispidus reached Kansas during the late Pleistocene and Early Pleistocene (Hibbard, 1960). This species was displaced southward into refuge in Florida and the American southeast during the Wisconsin glaciation (Blair, 1958) and again moved northward with the retreat of the glaciers. Serological evidence indicated that Florida and southwestern populations of S. hispidus did not rejoin, but that cotton rats from the Mexican plateau repopulated the area by moving northward (Daly and Lillievik, 1969).

Speciation of S. hispidus, S. arizonae, and S. nasoensis probably occurred during the mid-Pleistocene (Zimmerman, 1970). Zimmerman (1970) surmised a pre-Wisconsin habitat separation of hispidus and arizonae in southern Arizona and the region west of the Sierra Madre Occidental in Mexico. When the climate of southern Arizona became warmer and drier with the retreat of the glaciers, S. arizonae may have been more adapted to invade this area quickly; this northward movement of arizonae may have isolated the population hispidus at Yuma (Zimmerman, 1970; see Fig. 3).

Figure 2. Dorsal, ventral, and lateral views of cranium and lateral and occlusal views of mandible of Sigmodon hispidus texanus (female from 27 km N Austin, Travis Co., Texas). Scale represents 10 mm.

Figure 3. Map of southern North America and northern South America showing the distribution of S. hispidus. Cross-hatched area after Hall and Kelso (1959); stippled area after Herskovitz (1965). Closed circles indicate range extensions described in text.
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FORM. The pelage of S. hirsutus is grizzled with blackish or dark brownish hairs, interspersed with buffy or grayish hairs. The belly and underparts are white and in some individuals parts are white, while in others they are paler to dark grayish, sometimes faintly washed with buff. The tail is dark, coarsely annulated but only sparsely haired, the hairs not obscuring the annulations. Chipman (1965) described the pelage as remarkably uniform throughout the animal's life but with several molts occurring. Juvenile pelage becomes complete within a week after birth and is characterized by short hairs somewhat darker than those of the adult. A rapid molt to subadult pelage begins ventrally and ends dorsally and is completed within 5 to 6 months after birth; or slightly before the subadult molt is completed, the molt to adult pelage begins, following the same basic pattern but taking 2.5 to 3 months to complete. Usually another molt occurs at about 6 months of age but is irregular and has been termed a patch molt. Gardner (1948b) and Sherman (1951) described albino color phases of the cotton rat while Danforth and Schwentker (1949) described a coat color mutation they called "snowball" because of the white coloration. This mutation occurred twice in related substrains both derived from stock originally collected in Alabama. Sherman (1951) noted that two individuals taken in Florida were browner and blacker than normal, respectively. Gennaro (1968) found that coat color varied in New Mexico and related the variation to soil color differences and past dispersal events.

Female cotton rats possess 10 mammae including three pectoral and two inguinal pairs (Hall and Kelso, 1959) or one inguinal pair. Hall and Kelso (1959) and Meyer and Meyer (1944e) recorded that cotton rats (Meyer and Meyer, 1944e) also encountered two animals which had an extra pair of abdominal mammae (making a total of 12), and one animal which lacked the anterior pectoral pair (making a total of 10). According to Chipman (1965), one-month old females showed no teat pigmentation while at 2 months all females showed some pigmentation and at 3 months all females showed dark brown pigmentation. A week or 10 days prior to the birth of a litter, the teats become enlarged and develop a black coloration. The dark brown coloration returned after weaning if there was not a new pregnancy.

Dental formula for S. hirsutus is i 1/1, c 0/0, p 0/0, m 3/3, total 16. Dentition of M1 and M2 and p1 and p2 were described by Herskovitz (1953); incisors opisthodont, grooved or ungrooved; molar crowns high, plane, principle cusps lozenge-shaped; vestige of mesoloph absent; apices of molar and primary molars opposed and touching M1 and M2, confluent in M3 (absent until 1 to 2 months of age (Chipman, 1965)); second secondary folds (posterior cingula) absent in upper molars; first secondary folds absent in lower second and third molars; anterior internal folds absent in first molars; second primary fold of M2 short, less than one-half of length of first primary. S. hirsutus has the most hypsodont molars of any species of Sigmodon (Martin, 1979). Hypsodonty in cotton rats has been accompanied by the addition of accessory roots; S. hirsutus developed roots, and Martin (1951) further suggested that the processes of lamination and involution are continuing in this species and the masticatory platform provided by the roots is becoming sturdier. In addition, root capture (the movement of the ridge of dentin below the gum) is even more rapid as a recent evolutionary adaptation to grinding in this species.

Sprague (1941) described the hyoid apparatus of Sigmodon and suggested that Sigmodon should not be placed in the Cricetinae. Hamilton (1946) noted that the basulum of S. hirsutus was distinctively different than in other genera of Cricetinae, except for its great similarity to Orzyomys palustris palustris. Hooper (1962) described and illustrated the glans penis of S. hirsutus in detail and compared it with those of other supposed Sigmodon rodents. Rinker (1954) compared the myology of Sigmodon, Orzyomys, Neotoma, and Peromyscus and discussed their intergeneric relationships. Blank (1950) described the histology of the alveolar portion of the cotton rat and Goertz (1962) related adrenal gland and spleen weights to age, sex, and season.

FUNCTION. McNair et al. (1944) and Schweigert (1948b, 1948c) reviewed studies that determined the susceptibility of cotton rats to poliomyelitis and diphtheria infection. This led to increasing use of the cotton rat as an experimental laboratory animal and to studies of its nutritional requirements. Underhill (1965) described the vulva in utilizing a wide range of protein concentrations than S. fulvipes and suggested this may be related to the ubiquity of feeding habits of S. hirsutus. Clark and Jungblut (1960) determined that vitamin C was not stored in the cotton rat and that rats injected intravenously with vitamin C. It was determined that cotton rats require thiamine, riboflavin, pantothenic acid, pyridoxine, and choline in approximately the same quantities as the white rat. Increases in growth rates of 3% were noted when 2% liver extract was added to the diet. If sufficient tryptophan is not added to the diet S. hirsutus can be converted to niacin. Insolot increased growth rates.

Oxygen consumption of resting cotton rats was measured by Baker and Dunaway (1969). Oxygen consumption (cc g⁻¹ h⁻¹) ranged from 2.8 to 4.0 at 5°C, 2.4 to 4.0 at 19°C, 1.9 to 2.7 at 25°C, and from 1.2 to 1.9 at 25°C; Baker (1974) and Wagner (1970) also found that oxygen consumption was temperature dependent. In animals exposed to 9°C for one month prior to testing (also at 9°C), CO₂ production (cc g⁻¹ h⁻¹) was measured as 2.6±0.11 whereas rats not exposed to or slightly before the subadult molt was measured as 1.78±0.07. Bowers (1971) measured resting metabolic rate in several subspecies (O₂ consumption in cc g⁻¹ h⁻¹) with the following results: S. h. texanus, 1.31 (0.96 to 1.56); Arkansas, S. h. berlandieri, 1.33 (1.02 to 1.25); Lubbock, Texas; S. h. toltecus, 2.42 (2.11 to 2.89), Venacruz and Isla del Toro, Mexico. McClure and Randolph (1980) reported allocation of energy to growth and thermoregulation in S. hirsutus; Sealandier and Guess (1970) investigated thermoregulatory responses to stress.

The increase in metabolic rate with decreasing temperature must be compensated for to increase survival. Fleharty et al. (1975) suggested that cotton rats expend considerable energy for thermoregulation during winter in the northern part of their range and that fat deposition during the growing season could provide this energy. This was confirmed by Cameron et al. (1974) who reported that Kansas store similar what rats and than rats from Texas in summer, autumn, and winter, but not in spring. Depletion of body fat in the Texas population corresponded with low abundance of preferred foods, seasonal cessation of reproduction, and seasonal hot weather during summer, whereas Kansas rats exhibited their lowest fat content in the spring following cold winter temperature.

Energy content of cotton rats ranged from 5.30 to 5.39 kcal/g dry weight or 1.74 kcal/g live weight (Fleharty et al., 1975; Golley, 1969). Caloric value was not influenced by sex or reproductive stage, but seasonal influences were manifest as changes in fat composition. Golley attributed the spring depression in fat content (hence energy) observed in cotton rats to the relative abundance in food items. Cameron et al. (1974) reported a similar phenomenon (see above). Energy value of two litters was given by Fleharty et al. (1975) as 5.65 kcal/g ash free weight (85.5% water, 12.3% ash) or 0.79 kcal/g live weight. Kaufman et al. (1976) estimated digestibility as 78% for field and 82% for laboratory conditions. Randolph et al. (1977) and Petrides and Stewart (1969) reported similar digestibility figures; Fleharty and Choate (1973) reported 69%.

Kirksey et al. (1975) found that the tail of the cotton rat is important in temperature regulation. The metabolic rate of normal rats was significantly higher than that of rats without tails beginning at ambient temperatures of 4°C and 20°C. Tail temperatures also differed significantly within the same temperature range. Mean lower critical temperature for rats with tails was 30.8°C while for rats without tails it was 30.0°C, indicating significant tail loss from the tail in cold environments. Higher rates of water loss (8.6% greater) in rats without tails at high temperatures suggested difficulty in thermoregulating without a tail.

ONTOMETRY AND REPRODUCTION. Information on fertilization and implantation came from the study of post-partum mating by Meyer and Meyer (1944e). Copulation generally occurred between 3 and 6 h and ovulation between 6.5 and 12 h after parturition. Eggs lost their cumulus cells 21 to 22 h after parturition and post-partum eggs in the two-cell stage were found in uterine flushes after 30 to 32 h. Eggs reached the eight-cell stage by 56 h post-partum and blastocysts still possessing zona pellucida were encountered by 74 to 76 h. Eggs were not encountered in uterine flushes at 94 to 97 h indicating the probable occurrence of implantation by this time. Meyer and Meyer (1944e) included photographs of Sigmodon sperm avo eggs at various stages of development.

Gestation in cotton rats lasts approximately 27 days (Meyer and Meyer, 1944e; Randolph et al., 1977). Both studies found a bloody discharge on about day 10 of pregnancy; the latter study suggested the vulva was used as becoming dry and contracted, appearing closed, after day 10.

Litter size in S. hirsutus ranged from 1 to 15 (Goertz, 1965); Haines, 1961; Kilgore, 1970; Svirka, 1929). Animals from northern areas of the range had significantly larger litters. Haines (1970) found a mean litter size of 3.4 (range, 2 to 5; n = 5) in Lubbock Co., Texas (33°35'N) and 7.3 (range, 4 to 15; n = 25) in Douglas
Co., Kansas (38°57′N). Seasonal variation in litter size occurred in the northern population with April litters significantly smaller than those of July, September, and October. Bancroft (1969) reported results from Del Rio and Co. in late fall with a peak in August and a mean litter size of 7.6 (range, 6 to 9; n = 9); Fleharty and Choate (1973) reported a mean litter size of 6.8 from Kansas. McLennan and Gaens (1978) reported a peak in the spring from Montana with breeding concentrated to frost-free seasons in this same area. Prenatal mortality averaged 1.2% from oviposited and 4.0% from resorption of embryos with no pattern attributable to season or population density. Larger litters were reported as a response to a shortened breeding season and lack of winter breeding.

Reproductive patterns in the southern part of the species range differed from those in the northern portions. Cameron (1977) reported reproductive peaks in fall and spring and a mean litter size of 4.8 (range, 2 to 7; n = 18) for cotton rats in Texas. O’Farrell et al. (1977) reported a bimodal reproductive pattern in South Carolina with a mean litter size of 4.5 (range, 2 to 8; n = 139); they found no seasonal difference in litter size. Cameron (1977) and Hall and Dalquest (1963) found cotton rats breed throughout the year in Texas and Veracruz, Mexico, respectively. Bowder (1971) found no significant relationship between litter size and latitude in the southern portions of the range (from 8°41′N to 23°13′N) where litters were ranged from a mean of 2.5 (range 1 to 2) to a mean of 6.3 (range 2.5 to 12; n = 6). Smaller litters were found in moister habitats and larger litters in drier habitats; areas with marked seasonality in temperature or rainfall yielded females with larger litters.

The neonates of S. hispidus are well developed at birth. Svihla (1929) measured an average birth weight of 7.23 g (range, 6.5 to 8.0; n = 19) and mentioned that they are able to run about very well, though their eyes are still unopened. Meyer and Meyer (1944a) gave an average birth weight of 6.8 g (range, 3.5 to 8.0; n = 184) and noted the average weight of young appeared to vary with the size of the mother and the number in the litter. The major increase occurred after opening their eyes between 18 and 30 days after birth with two of 197 opening their eyes within 2 days of birth. Three young did not open their eyes until 60 to 65 days after birth. Young are covered by a fine coat of light-colored hair at birth, thickest around the head, with a reddish-brown surface of the dorsal surfaces of the head, back, and tail is slate grey and the under-surfaces are pink. Young are easily sexed at birth due to the presence of a dark pigmented area in the scrotal region (Meyer and Meyer, 1944a).

Young cotton rats grow rapidly, gaining about 1 or 2 g per day (Fleharty and Choate, 1973; Meyer and Meyer, 1944a; Svihla, 1929). They can be weaned at 10 to 15 days of age with the earlier weaning resulting in retarded growth rates (Keys, 1958; Meyer and Meyer, 1944a; Svihla, 1929).

Jimenez (1972, 1979) found that body growth can be divided into three periods: from 0 to 40 days, length of all body dimensions increases rapidly; from 40 to 100 days, the increase is moder-ately slow; after 100 days onward, the increase practically no longer occurs. In contrast, skull growth is divided into two phases: birth to 100 days and 100 days to maximum adult size. Most skull dimensions reach minimum adult size during the first 100-day period. Chipman (1965) followed developmental trends in 316 known-age cotton rat and judged that a combination of body length, molting stage, epiphyseal fusion, skull measurements, and dry-lens weight accurately aged cotton rats up to 6 months. Green and Jameson (1973) found a significant relationship between age and the width of the zygomatic arch (a measurement that does not require sacrificing the animal) and classified animals with a width <18.5 mm as juveniles and those >18.5 mm as adults. Birney et al. (1977) found that body weight as a reliable criterion for age determination only through the first 70 days. Eye lens weight and insoluble lens protein were roughly equal in age predictability up to 130 days when insoluble protein became the best criterion.

In cotton rats, pregnancy in males can be determined by the presence of sperm in the epididymis. Chipman (1965) found that testes descended and remained in the scrotal sac between 2 weeks and 1 month of age; sperm were found in the epididymis of 2 out of 5 free 2-month-old males and all 3-month-old males observed. Meyer and Meyer (1944a) also observed this pattern with some variation. Seasonal variation in both sexes is very important (Ewing et al., 1965; Goertz, 1965a; Haines, 1961). Open vaginas are usually encountered between 50 and 40 days of age (Meyer and Meyer, 1944a) and earliest occurrence in females (O’Farrell et al., 1977) was open by 50 days of age. Chipman (1965) observed a pregnancy with conception occurring at the age of 38 days, impregnation was by a litttenate. Meyer and Meyer (1944e) observed a conception at 40 days of age, also by a litttenate. They also observed animals showing signs of estrus at the age of 10 days.

Dunaway and Koprowski (1960) reported that female body weights were heavier than those of males during breeding but not non-breeding seasons. Rate of weight gain was influenced by weather. The energy cost of reproduction was a function of litter size. Randolph et al. (1978) reported that females undergoing pregnancy were stored at fat and mobilized during lactation. Vaginal estrus was first described by Clark (1936) and then by Meyer and Meyer (1944a). Average cycle lengths of 28 to 9 days are considered variable. Improvement was initiated by a period of marked leucocyte reduction and increased in nucleated epithelial cells which eventually completed the entire vaginal smear. Proestrus lasted from 12 to 21 h with a mean of 14 h. Estrus varied from 21 to 123 h, averaging 46 h, and consisted of great numbers of corporal celles. Metestrus lasted from 9 to 21 h, averaging 14 h, and first consisted of nucleated epithelial cells followed shortly by leucocytes. Diestrus varied from 42 to 156 h, averaging 116 h. In young females, a mass of white tissue protruded from the vagina which, when removed, formed an internal cast of the vagina. Chipman (1967) found that the cast consisted mainly of well-nucleated epithelial cells and suggested that all female cotton rats produce this cast upon giving birth and then during puberty. Meyer and Meyer (1944a) found that environmental disturbances (changes in light, noise) affected cycles of laboratory-caged cotton rats.

ECOLOGY. Trap biases which must be corrected to accurately describe parameters of S. hispidus populations have been reported. Wiegert and Mayensche (1966) reported differential trappability affected density estimates. Social structure also influences trapping success (Boule and Cameron, 1974; Summetlin and Wolfe, 1973); dominant animals were more prone to trapping than subordinates. This was caused by a neophobic response by subordinates, avoidance of traps with conspecific scent, or subdued or less active exploratory behavior (Boule and Cameron, 1974; Summetlin and Wolfe, 1971). Cameron (1977) employed temporary removal trapping to alleviate these biases; Hall (1974) suggested a correction factor based on age.

Significant exhibited bimodal population fluctuations annually in the southern portion of its range (Texas: Cameron, 1977; Raun and Wilks, 1964; Georgia: Odum, 1955; Mexico: Petersen, 1973; and Florida: Layne, 1947). Maximum densities occurred during autumn and there were small spring peaks (Texas 14/ha, Georgia 69/ha, Mexico 51/ha, Florida 25/ha); minimum densities occurred during winter or summer (Texas 0.5/ha, Georgia 8/ha, Mexico 25/ha, Florida 10/ha). Density patterns were not bimodal in northern areas of the species range. Fleharty et al. (1973) reported an autumn peak with a secondary peak (minimum density 0.02/ha) in Kansas. McLennan and Gaens (1978) reported similar phenology in eastern Kansas with a minor peak in early summer.

Cameron (1977) computed the mean expectation of further life (average duration of residence for all individuals) for S. hispidus males as 1.96 months and females as 2.2 months. The longest period of residence for both sexes was 9 to 10 months. Petersen (1973) determined the high cotton rat primarily ate grasses. They noted distinct dietary preferences and selection of food items from a wide environmental array. Kincaid (1975) and Gaertner (1968) showed seasonal utilization of insects by cotton rats.

Layne (1974) reported average home ranges for adults (0.35 ha), subadults (0.22 ha), and juveniles (0.35 ha). Fleharty and Mares (1973) computed a home range of 0.39 ha for males and 0.22 ha for females. Male S. hispidus have larger home ranges than females (O’Farrell et al., 1977; Eickholt and Mares, 1973; Goertz, 1964; Layne, 1974), but females have exclusive home ranges (Cameron et al., 1979; Fleharty and Mares,
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1973; Layne, 1974). Adults have larger home ranges than young adults (Cameron et al., 1976; Layne, 1974).

Seasonal differences in movements appeared to be influenced by the stage of estrus. Females that had lost cover in their estrus (Bergler and Jenkins, 1975; Briese and Smith, 1974; Fleharty and Marees, 1973; Layne, 1974; Smith and Vrieze, 1979). Cameron et al. (1979c) reported an average daily movement of about 13 m (combined sex and age groups). These data also suggest that females averaged 17 m when females averaged 21 m. (Bergler and Jenkins, 1975) reported females moved slightly farther than males in Florida although they felt this may reflect grid size. Cameron et al. (1979c) determined that reproductive males moved farther than nonreproductive males; there was no such difference among females.

Dispersal of S. hispidus was positively correlated with density (Joule and Cameron, 1975); sex ratio and age structure of dispersers was similar to those of the source population. Lindzich (1975) characterized this pattern as pre-saturation dispersal.

Ramsey and Briese (1971) and Bigler et al. (1977) showed that intraspecific interactions affected density and movement patterns of S. hispidus. Allen introduced into an experimental population of 56 females; cottontails probably influence pygmy mice through behavioral interactions; this restriction decreased their survival (Bigler et al., 1977). Roads are effective barriers to S. hispidus movement (Joule and Cameron, 1974; Kozel and Flessner, 1973).

Interspecific interactions have been reported between S. hispidus and several other rodent species. Raun and Wilks (1964) suggested competition with Baiomys taylori for forage in suitable habitat. Later, Raun (1966) found that pygmy mice are the most important competitor of S. hispidus. Petersen (1973) suggested competition between S. hispidus and S. fulvidraco in Mexico because fulviveae was numerically and interactively dominant. Subsequent laboratory trials confirmed negative behavioral interactions (Petersen and Helland, 1978); S. fulvidraco was more aggressive whereas S. hispidus avoided encounters. Over half of the encounters resulted in neutral or amicable behavior, suggesting that S. fulvidraco was a much more important competitor of S. hispidus than aggression in the field. Baker (1971) suggested that Sigmomay be behaviorally ignored. Terman (1974) noted in the laboratory that S. hispidus was not interbreeding with M. ochrogaster from confined areas except where contact was dense. Terman suggested that the frequency of contact was related to the other species. The compelling effect of thicker cover explained an increase in numbers of M. ochrogaster because of a decreasing number of interspecific contacts. Increases in density of S. hispidus cause a decrease in density of M. ochrogaster because of increasing frequency of contact. Glass and Slade (1980) found M. ochrogaster negatively affected M. ochrogaster populations during the cotton rats' reproductive season. Cameron (1977) suggested behavioral competition was significant. Interactions between S. hispidus and Reithrodiromyys fulvescens.

Korschgen and Stuart (1972) documented a reliance by some avian predators on cotton rats in Missouri; deviations in the general movements of cotton rats over a 24-hour period were due to high concentrations on cotton rats (during years of high densities of cotton rats). Similarly, cotton rats were the primary food of barn owls in Texas (Raun, 1966). These authors suggested that utilization of cotton rats by avian predators resulted in decreased use of other prey. Schnell (1968) noted that avian predators were critically important in regulating densities of cotton rats in enclosures and that this was a density-dependent process. Avian predators reduced numbers of cotton rats to the carrying capacity of cover; whereas mammalian predators did not exert a density-dependent effect and were considered incidental (Weigert, 1972).

Roberts and Wolfe (1974) related social rank of cotton rats to their susceptibility to avian and mammalian predation. A mammalian predator (house cat) selected dominant animals more frequently whereas an avian predator (red-tailed hawk) selected subordinate animals. These differences were attributed to the predator's hunting strategy and the differential activity of dominant and subordinate animals.

Prairie cotton rats in western Kansas ingest less than 1% of the annual net primary production (Fleharty and Chaote, 1973); 98% of this energy was utilized for maintenance costs. S. hispidus removed 0.5% of the annual primary production by clipping (Petrzyzn and Fleharty, 1972). Seasonal variation in the energy budget reflected physiological adjustments to environmental variation (e.g., fat deposition, breeding).

Fecundity of cotton rats varied significantly with age, sex and season in cotton rats (Gentry et al., 1975). Estimates of consumption, eggestion, and assimilation of elements were used to evaluate the influence of small mammals in nutrient flow in an ecosystem (Gentry et al., 1975; Kaufman et al., 1976). Two elements may be limiting to S. hispidus: Ca in the fall and P in the spring and fall. Sigmomod sp. exhibited a high resistance to radiation (Pelton and Provost, 1969). Survivors of irradiated individuals was not different from that of controls in the laboratory or in a field experiment (Barnett, 1975). Radiation survival changed in radiocesium (Barnett, 1975). Seasonal variation in diet, and in reproduction, were the major factors that determined the effect of a decrease in population size. This was the result of a decrease in population size of a competing species (Mus musculus).

Sigmomod sp. supports a variety of internal and external parasites. Kinsella (1974); Mollahan (1978); and Coggins (1972) listed helminth parasites (including trematode, cestode, and nematode species) from the digestive tract and pleural cavity. Host habitat and availability of intermediate hosts influenced the magnitude of the parasite load. Comparison between Texas and Florida suggested that anidry is partly responsible for the reduction in helminth populations. Coggins (1972) noted the importance of S. hispidus in the decrease in winter. Coggins (1972) also noted that Sigmomod sp. is a reservoir for numerous human diseases, including rabies, Chagas disease, and Venezuelan equine encephalomyelitis (Bigler and Jenkins, 1975; World Health Organization, 1974).

BEHAVIOR. Cotton rats are active at all hours of the day and night, they exhibit a labile activity pattern influenced by biotic and abiotic factors (Calhoun, 1945). Cameron et al. (1979) found activity peaks in southeast Texas field populations at 0900 and 0900 h with minimal activity from 2300 to 0500 h (a crepuscular pattern). Kilduff and Christman (1978) studied activity patterns in the laboratory. Activity began just after dawn and declined until dawn lasting about 1L:14D photoperiod while there was a noticeable peak around dawn under 14L:10D. They concluded that Sigmomod sp. is probably a nocturnal animal. Animal activity pattern is a labile pattern during dark hours. Stevenson et al. (1968) also found Sigmomod sp. to be primarily nocturnal.

Ehser et al. (1978) investigated the swimming behavior of hispid cotton rats. While swimming, cotton rats used mainly the hind feet for propulsion while holding the forefeet near the body. They were never swimming under water. Fur of cotton rats was not as water repellent as that of the more aquatic rice rats (Oryzomys palustris), becoming wet almost immediately upon immersion and giving the rats a tendency to sink. Swimming stamina of cotton rats was good. Bodies of water do not form a significant barrier to cotton rats.

The building and utilization of nests by hispid cotton rats has been described (Laar et al., 1974; Dawson and Lang, 1973; Halley, 1977; Hanley, 1977; Hanley, 1978). In the laboratory, Shump and Hanley (1978) found that nests were made of woven grass and ranged from cup-shaped to hollow ball-shaped structures with a single entrance. Shump (1978) found that nests constructed by rats from Kansas were woven more tightly, significantly larger, and twice as insulative as Florida nests; he suggested that behavioral plasticity in nest-building was responsive to climatic conditions. Orientation of nest openings was most often toward the southeast to decrease cooling of the nest by cold northwest winds and allow penetration of sunlight on cold winter mornings (Shump, 1978). Shump and Christian (1978) analyzed the relationship between soil type, burrowing activity, and nest type.

Harriman (1977) demonstrated that hispid cotton rats select ed available food items and combined them into a nutritious diet. Cotton rats fed a diet consisting of types and amounts of foods selected by other cotton rats exhibited significantly greater weight gains than animals fed laboratory chow. In laboratory tests, Harriman (1970) and Lanier et al. (1974) found no evidence of food hoarding by cotton rats.

Copulation is characterized by the absence of a lock, a cessation of thrusting during intromission, multiple intromissions preceding ejaculation, and multiple ejaculations (Barnett, 1972, 1975). Post-ejaculatory copulation with no sperm transfer was observed.

Female cotton rats make exceptionally fine mothers (Meyer and Fisher, 1944). During their suckling, young were killed by their mothers even after both mothers and young were handled by the investigators. Females also made good foster mothers even


Cameron, G. N., W. B. Kincaid, and B. A. Barnes. 1979. Experimental species removal: temporal activity for young albino laboratory rats. Layne (1974) noted that on four separate occasions, while juveniles or subadults were being handled in the field, an adult approached to within a few feet in response to squeaking by the young.

Wright and Pagels (1977) determined that hispid cotton rats climb in above-ground vegetation. In a trapping effort consisting of 33 trap-nights, five cotton rats were captured at a mean height of 202.2 mm (160.3–276.0) in vines of Japanese honeysuckle (Lonicera japonica).

Debusk and Kennerly (1975) found that homing in the cotton rat occurred from distances of 100 m to 1,500 m with success decreasing with distance. Of 166 rats displaced, 112 successfully returned to their home area with the highest proportion being those displaced up to 300 m. They concluded that cotton rats released up to 300 m away from their home areas probably were still on familiar ground but either navigation or random wandering could have been involved in instances of longer homing.

Liu (1971) described S. hispidus "as a solitary species, since its only prolonged social contact is between male and female, and even this contact depends upon the female's reproductive status." In the laboratory, male-female pair bonds are formed and are characterized by frequent physical contact (sleeping, huddling, and mutual grooming; huddling was also reported by Dunaway and Kaye, 1961). Males are dominant over females in these pairs.

Agonistic behavior is an important factor influencing social organization. Disorganized groups of S. hispidus exhibited significantly fewer agonistic encounters and groups that showed significant decreases in agonistic encounters after 24 h of interaction (Wolfe and Summerlin, 1968). They suggested that social behavior of hispid cotton rats in nature is characterized by a relative dominance system (Bromson, 1964). Summerlin (1968) described threat and appeasement postures for this species. Development of behavioral traits in young cotton rats is very rapid. Liu (1971) described the onset of adult characteristics and found that young could survive without maternal assistance at an age of five days.

GENETICS. The most widely distributed karyotype of Sigmodon hispidus consists of a 24 number of S and a FN of 52 and occurs from the eastern United States (Zimmerman, 1970) to Venezuela (Kiblisky, 1969). The karyotype consists of 48 acrocentric and two very small metacentric autosomes. Sex determination is of the XX:XY type; the X chromosome is usually large and subtelocentric and the Y chromosome varies from medium-small metacentric to submetacentric (Zimmerman, 1970). Zimmerman (1970) described chromosomal polymorphisms which included Robertsonian variation and persistent insertions in autosomes and also polymorphism and geographic variation in the sex chromosomes. Chromosome numbers ranged from 2n = 51 (probably chelifer formation) to 2n = 56 (addition of supernumerary chromosomes). Comparative male meiosis in seven species of cotton rats was described by Zimmerman (1974). Chromosomal and serological evidence suggested that a form similar to S. hispidus could have been the ancestor to all the species in the genus (Dalby and Lillevik, 1970).

Johnson et al. (1972) investigated genetic variation among and within cotton rat populations by electrophoresis of 23 enzymatic and non-enzymatic proteins. Average heterozygosity was 2.14% (1.77 to 2.61%) with most of the heterozygosity contributed by two loci, PGC-3 and PGC-G. Average genetic similarity across populations, S = 0.9084 (0.907 to 0.908), indicated a high degree of geographic uniformity. However, Dalby and Lillevik (1969) assigned individuals to geographic regions on the basis of different transferrin patterns. McLennan (1980) and McLennan and Gains (In press) reported higher mean levels of heterozygosity per individual (5.4%) in Mexico and 4.94% (Kansas). Marginal (Kansas) populations of S. hispidus exhibit higher levels of genetic variability than populations found centrally (Mexico) within the species distribution. McLennan (1980) found lower levels of heterozygosity (2.23 to 2.85%) at three localities within the isolated S. hispidus population in the Colorado River Valley of California and Arizona (see Fig. 3). Only two of 23 loci were polymorphic, the lower levels of variability presumably due to the founder effect. This isolated population is very similar genetically to cotton rats from the contiguous areas where the possibility of gene admixture is low.

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